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Further search for a neutral boson with a mass around 9 MeV/c²

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Abstract

Two dedicated experiments on internal pair conversion (IPC) of isoscalar M1 transitions were carried out in order to test a 9 MeV/c² X -boson scenario. In the ${}^7\text{Li}(p, e^+e^-){}^8\text{Be}$ reaction at 1.1 MeV proton energy to the predominantly T=0 level at 18.15 MeV, a significant deviation from IPC was observed at large pair correlation angles. In the ${}^{11}\text{B}(d, ne^+e^-){}^{12}\text{C}$ reaction at 1.6 MeV, leading to the 12.71 MeV 1^+ level with pure T=0 character, an anomaly was observed at 9 MeV/c². The compatibility of the results with the scenario is discussed.

1. Introduction

A neutral boson can in principle be emitted in a nuclear transition within the constraints of spin-parity and energy-momentum conservation. In magnetic transitions such a boson should have a pseudoscalar (0^-) or an axial vector (1^+) character, and in electric transitions a scalar (0^+) or a vector (1^-) character. When its mass is above 1.022 MeV, the signature of X -boson emission could be the two-body decay into e^+e^- pairs superposed on conventional internal pair conversion (IPC) [1]. In a survey [2, 3] of data for IPC of transitions in several nuclei [4-8] with energies above 10 MeV, an anomaly with respect to IPC appears at an invariant mass of approximately 9 MeV/c². Whereas (partial) isoscalar M1 transitions exhibit an excess of e^+e^- pairs at large opening angles no deviations occur in isovector E1 and M1 transitions [4]. Interpreting this anomaly in the perspective of a short-lived ($\tau \leq 10^{-10}$ s) neutral X -boson of 9 MeV/c² [2, 3], the deviations in isoscalar M1 transitions would indicate an isoscalar character for such a boson with spin-parity 0^- or 1^+ .

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AZ	E_R MeV	Γ_R eV	I^π, T	E_γ MeV	B_X	Γ_X meV	α_X $1.7 \cdot 10^{-6}$	m_X MeV/c ²	Refs.
^{12}C	12.71	18.1	$1^+, 0$	12.71	$(7 \pm 3) \cdot 10^{-4}$	0.24 ± 0.11	18 ± 7	9.0 ± 1.0	present
				12.71	$(1.6 \pm 0.7) \cdot 10^{-3}$	0.56 ± 0.25	38 ± 17	9.2 ± 1.0	[5-7]
^8Be	15.11	43.6	$1^+, 1$	15.11	$\leq 4.6 \cdot 10^{-5}$	≤ 1.8	≤ 0.9	-	[5-7]
	17.64	$10.7 \cdot 10^3$	$1^+, 1$	17.64	$(1.1 \pm 0.3) \cdot 10^{-4}$	1.9 ± 0.4	1.5 ± 0.4	9 ± 1	[2-4]
				14.64	$(8.5 \pm 2.6) \cdot 10^{-5}$	0.7 ± 0.2	1.5 ± 0.4	9 ± 1	[2-4]
	18.15	$138 \cdot 10^3$	$1^+, 0$	18.15	$\leq 4.1 \cdot 10^{-4}$	≤ 1.2	≤ 5.7	-	present
^4He				15.15	$(5.8 \pm 2.2) \cdot 10^{-4}$	2.2 ± 0.8	10.5 ± 4.5	9.5 ± 1.2	present
	21.0	$850 \cdot 10^3$	$0^-, 0$	M0	$0^- \rightarrow 0^+, e^+e^-$	74 ± 30	32 ± 12	8 ± 2	[5-7]

Table 1: *Experimental results for anomalous e^+e^- -emission interpreted in the light of a short-lived 9 MeV/c² X-boson in six M1 transitions and an M0 transition. Listed are the nucleus, the energy and the width of the resonance E_R and Γ_R , the (iso)spin-parity quantum numbers, the transition energy E_γ , the X-branching ratio B_X with respect to γ -emission, the X-decay width Γ_X , the coupling strength α_X relative to $\tilde{\alpha} = 1.7 \cdot 10^{-6}$ (the axion-nucleon coupling strength), the invariant mass m_X , and the references. Values for B_X and m_X have been derived at 95 % CL.*

The branching ratio [2, 3] for emission of an elusive X-boson with respect to γ -emission in nuclear dipole transitions can be written as

$$B_X = \frac{\alpha_X}{2\alpha} \beta^3, \quad (1)$$

where α_X is the the isospin dependent effective boson-nucleon coupling strength, relative to $\tilde{\alpha} = 1.7 \cdot 10^{-6}$ (the axion-nucleon coupling strength), α the fine structure constant. Measured values for B_X , Γ_X , α_X and m_X for the different M1 transitions are listed in Table 1. Results from the previous studies have been included. The average m_X is found to be (9.1 ± 0.4) MeV/c².

The investigations were triggered, about a decade ago, by the observation of e^+e^- pairs in an emulsion study [9, 10] at short distance from the interaction vertex, using ^4He , ^{12}C and ^{22}Ne projectiles at 4.5 GeV/A and ^{32}S at 200 GeV/A. In a plot [2] of the invariant mass m_X against the lifetime τ , derived from the observed parameters of the pairs, a distinct cluster of 10 events with average invariant mass of 8.8 MeV/c² and lifetime of $6 \cdot 10^{-16}$ s was observed, with a background of external pair conversion (EPC) [11] from γ -rays mostly from π^0 decay.

In the field of very high energy cosmic-ray interactions, possibly related results came from the the JACEE collaboration [12, 13]. In emulsion chambers multiple electron pairs were observed in heavy particle decays, which could not be explained in terms of known decay modes. However, the pairs were found to be consistent with the hypothesis that some as yet unidentified, light neutral particles with masses less than 100 MeV/c² were emitted in bottom decay, which subsequently decayed into e^+e^- pairs. Quite recently, revisiting the data, the observations were reported [14, 15] to be not inconsistent with a light neutral boson with a mass of 9 MeV/c² and lifetime of $1.4 \cdot 10^{-15}$ s.

On the basis of the available data on the IPC anomaly [2, 3] an X-boson scenario has been proposed, where X stands for an isoscalar pseudoscalar particle, with its

coupling strength α_X proportional to the isoscalar strength of the M1 transition. However, the isoscalar strength in a nuclear transition is in general unpredictable, because even a relatively small—mostly not well known— $T=1$ component in one of the levels gives a predominant isovector contribution. This in turn is because the isovector strength is typically two orders of magnitude larger than the isoscalar strength. In addition, both the isovector and isoscalar strength range over three orders of magnitude (see Fig. 5). Hence, the sensitivity for detection of an X -boson signal in a given M1 transition from a primarily $T=0$ level with a substantial $T=1$ component can be estimated only by order of magnitude. From Table 1 it can be inferred that the sensitivity of the X -boson searches—expressed in the ratio of Γ_X to Γ_R —varies between 10^{-8} and 10^{-5} .

2. New Experiments

In order to test the X -boson scenario, a dedicated search of e^+e^- angular correlations in isoscalar transitions is mandatory. The signal observed [2] for the relatively pure isoscalar M1 ground state transition from the 1^+ , $(99.87 \pm 0.12)\%$ [16] $T=0$ level at 12.71 MeV in ^{12}C should be checked at a high level of significance. For this particular transition the isoscalar strength can be deduced from Γ_γ with 20 % accuracy because of the very small (0.0021) $T=1$ fraction in the level.

To perform such a test, new experiments were carried out at the Institut für Kernphysik in Frankfurt (IKF) using the proton and deuteron beams of the 2.5 MV Van de Graaff accelerator. The detector was the same as the one used in the previous experiments [17, 18]. It consists of eight ΔE - E plastic detectors mounted at various angles. Combinations of these telescopes cover an e^+e^- correlation angular range from 20° to 130° , which corresponds to a window of the invariant mass of 3 to 15 MeV/ c^2 for a neutral boson at a transition energy of 18 MeV for coincidences between electrons and positrons.

For absolute normalisation of the population of relevant nuclear levels, a large 135 cm^2 Ge(Li) detector was used as monitor. It was mounted under 90° with respect to the beam direction in order to minimise Doppler broadening. The FWHM resolution was ~ 20 keV at 6.13 MeV and ~ 30 keV at 17.64 MeV, sufficient to separate photo peaks, single escape and double escape peaks of the relevant γ -transitions.

As a consistency check of the apparatus and its calibration, the angular correlation of electron-positron pairs in the $0^+ \rightarrow 0^+$ E0 decay from the 6.05 MeV 0^+ level in ^{16}O following the $^{19}\text{F}(p, \alpha e^+e^-)$ reaction at 1.6 MeV was remeasured [17, 18].

In addition, the null effect for the E1 decay from the 1^- level at 17.23 MeV in ^{12}C was verified by remeasuring the $^{11}\text{B} + p \rightarrow ^{12}\text{C}$ capture reaction at 1.6 MeV [4].

2a. The $^7\text{Li}(p, e^+e^-)^8\text{Be}^*$ reaction at 1.1 MeV

In the 1^+ level at 18.15 MeV in ^8Be , the isoscalar component amounts to 90% compared to 5% [19, 20] in the 17.64 MeV level, where the anomaly was first observed. Assuming that the isoscalar transition strengths T_S of the transitions to the pure $T=0$ ground state and the first excited state—with similar energies and in the

same nucleus—scale with the $T=0$ component of the depopulating level, a factor twenty larger anomaly may be expected in the transitions from the 18.15 MeV level, compared to what was actually measured [4] for the 17.64 MeV level.

The angular correlation of the e^+e^- decay from the 18.15 MeV resonance at 1.05 MeV was studied by means of the ${}^7\text{Li} + p \rightarrow {}^8\text{Be}^*$ capture reaction at a proton energy of 1.1 MeV, for a period of four days. Targets of natural Li_2O with typical thicknesses of $600 \mu\text{g}/\text{cm}^2$ were used. From an analysis of the $\text{Ge}(\text{Li})$ γ -spectrum, it follows that the 17.64 MeV level is populated by 25% with respect to the excitation of the 18.15 MeV resonance.

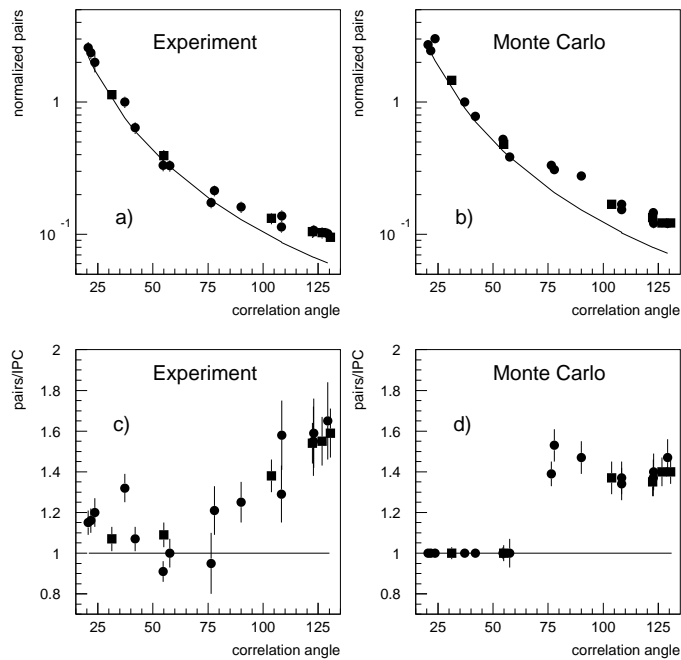


Figure 1: Angular correlation of e^+e^- pairs following the ${}^7\text{Li}(p, ne^+e^-){}^8\text{Be}$ reaction at 1.1 MeV bombarding energy, for a) data for the 18.15 MeV resonance in ${}^8\text{Be}$ with IPC prediction (solid curve); b) GEANT Monte Carlo simulation [2] of e^+e^- pairs of the 15.15 MeV transition from the 18.15 MeV level to the first excited state due to IPC (solid curve) and additional pairs originating from the two-body decay of a neutral boson with a mass of $9.5 \text{ MeV}/c^2$ and a branching ratio of $5.8 \cdot 10^{-4}$; c) the ratio of the values from above (a) divided by the corresponding IPC values; similarly, d) the values of (b) divided by the corresponding IPC values. Circular dots denote correlations between the six "small" detectors, squares between "small" detectors and one "large" detector [4, 17, 18].

In Fig. 1a the experimental angular correlation is displayed for e^+e^- pairs integrated over all sum energies of the different angular combinations. Fig. 1c shows the measured values divided by IPC. The data are normalised to unity for the correla-

tion angles at 42° , 54.6° and 57° . At these angles contributions from EPC can be neglected. An excess of pairs is observed above 76° rising towards the largest angles. However, this is different from expectations since GEANT MC simulations for emission of a 9 MeV/c² boson in the ground state transition yield an enhancement starting at 55° . From a comparison with the simulations an upper limit of $4.1 \cdot 10^{-4}$ is derived for the X -boson branching ratio in this transition. We note that in case of a slight boson excess at the normalisation angles, any possible evidence for a large angle enhancement would decrease.

The excess at large angles can be consistent with X -boson emission in the 15.15 MeV transition depopulating the 18.15 MeV resonance to the first excited state in ^8Be . This is illustrated in Figs. 1b and 1d displaying MC simulations for a 9.5 MeV/c² X -boson in the 15.15 MeV transition with a branching ratio of $(5.8 \pm 2.2) \cdot 10^{-4}$.

2b. The $^{11}\text{B}(d, ne^+e^-)^{12}\text{C}^*$ reaction at 1.6 MeV

In the X -boson scenario [2, 3] a strong e^+e^- signal [5, 6, 7] with a branching ratio with respect to the γ -ray intensity of about half the IPC coefficient of $2.7 \cdot 10^{-3}$ can be expected [2, 3] for the pure isoscalar M1 transition from the 12.71 MeV 1^+ , T=0 level to the ground state in ^{12}C . The $^{12}\text{C}(p, p')^{12}\text{C}^*$ and the $^{11}\text{B}(d, n)^{12}\text{C}^*$ reactions at subthreshold beam energies for the 15.11 MeV 1^+ , T=1 level appear to be appropriate to investigate the 12.71 MeV resonance. Using the IKF Van de Graaff accelerator we could utilise the $^{11}\text{B}(d, ne^+e^-)^{12}\text{C}^*$ stripping reaction at a deuteron energy of 1.6 MeV leading to the 12.71 MeV 1^+ level with a σ_γ of 1.2 mb [21]. Unfortunately the parallel excitation branch $^{11}\text{B}(d, p)^{12}\text{B}$ forms several sources of background:

1. The ^{12}B ground state decays with a β^- -spectrum (endpoint 13.17 MeV) with a cross-section as large as 380 mb [21] in 97.1% of the cases to the ^{12}C ground state with $t_{1/2} = 20.2$ ms. Random β^- coincidences produce a broad background, with maximum energy at ~ 13 MeV, which—dependent on beam intensity—can completely obscure the 12.71 MeV sum-energy peak of interest.
2. The 1.3% β^- -branch populating the first excited state at 4.44 MeV followed by internal (IPC) [1] and external (EPC) γ -conversion [11] allow real coincidences to produce a broad distribution with a maximum around 6 MeV.
3. The 3.4 MeV e^+e^- sum-energy peak of the 4.44 MeV level in ^{12}C appears as intrinsic background, being partly directly populated in the (d, n) reaction.

These background sources were largely suppressed by implementing a beam pulser into the beam line. The beam was periodically deflected from the target into a Faraday cup. The period on target and the deflection time could be adjusted over a wide range. A beam on/off setting of 1.0/100 ms was found optimal.

In the production runs the total beam intensity had still to be limited to 4 μA , the beam on target being 40 nA. Two targets were used, one consisting of more than 99.9% enriched ^{11}B with a thickness of 600 $\mu\text{g}/\text{cm}^2$ sandwiched between 2 μ thick titanium foil, manufactured at JINR (Dubna). The other was made at KVI

(Groningen) and consisted of 98% enriched ^{11}B evaporated with a thickness of $600\ \mu\text{g}/\text{cm}^2$ on a $2\ \mu$ thick gold foil. In a two weeks period an effective beam time of 100 hours was reached with the KVI target in place. For the Dubna target a shorter beam time of 44 hours was left to accumulate which is reflected in the larger error bars. The occurrence of p -capture on ^{11}B from any accelerated molecular hydrogen (contamination in the deuterium gas bottle) was suppressed by a gas stripper in front of the analysing magnet of the Van de Graaff accelerator.

The population of the 12.71 MeV level in the $^{11}\text{B}(d,n)^{12}\text{C}$ reaction was obtained by detecting in the Ge(Li) detector the 12.71 MeV and 8.27 MeV γ -rays to the ^{12}C ground state and first excited state. In the γ -ray spectra from both targets a peak occurs at 7.64 MeV from the decay of the degenerate 3^+ and 2^+ levels at ~ 9.35 MeV in ^{28}Si . These levels are selectively populated in the $^{27}\text{Al}(d,n)$ reaction [23], presumably due to (beam halo) deuterons reacting with the aluminium target frames. Moreover, a contamination of 2% ^{10}B in the KVI target inducing the $^{10}\text{B}(d,p)^{11}\text{B}$ reaction [22-24] caused a strong contribution of γ -rays at 4.49, 6.76 and 8.92 MeV.

Random coincidences due to the remaining β^- background were subtracted by selecting windows on the prompt and delayed parts of the time spectra. In the sum-energy spectra obtained in this way for the different runs, a complex of several sum peaks could be identified at 21.8° , one of the smallest correlation angles between neighbouring detectors, which contain the highest statistics but also a substantial EPC contribution, and at the correlation angles 37.2° , 42.0° and 54.6° (see Fig. 2). Sum-energy lines corresponding with the observed γ -ray transitions are indicated. A comparison of the widths of the 4.44 MeV sum-energy lines in the KVI and Dubna spectra shows that the $2\ \mu$ supporting titanium layer does not notably influence the resolution in the latter spectrum.

A global analysis of the spectra has been made by integrating the yields of the spectra in four 4 MeV wide intervals without attempting to fit the complex structures. In Fig. 3 from top to bottom the background subtracted angular correlations are exhibit for the two targets. The curves show parameterised functions [18, 25] representing the theoretical [1] IPC angular distributions of M1 transitions. Like for the ^8Be experiment, they are normalised to unity for the correlation angles at 42° , 54.6° and 57° , where EPC is not expected to contribute significantly. A fair agreement with IPC assuming M1 character is observed over the whole angular range for e^+e^- pairs in the first two intervals with sum-energies below 8 MeV. Deviations from IPC show up for the 8 - 12 MeV and 12 - 16 MeV intervals.

The correlation of the e^+e^- pairs in a 4 MeV window around the sum-energy peak of the 12.71 MeV transition is shown in the top figures of Fig. 4. A clearly visible but statistically marginal enhancement over IPC shows up at large correlation angles $\geq 90^\circ$ for both the KVI and the Dubna target. In the bottom figures these distributions are divided by the corresponding IPC values. They are normalised to unity for the correlation angles between 40° and 60° . The combined statistical significance amounts to 3.5σ .

A comparison with the simulations for the two-body decay of a short-lived neutral boson yields an invariant mass of $(9\pm 1)\ \text{MeV}/c^2$ and a branching ratio of $(7\pm 3)\cdot 10^{-4}$,

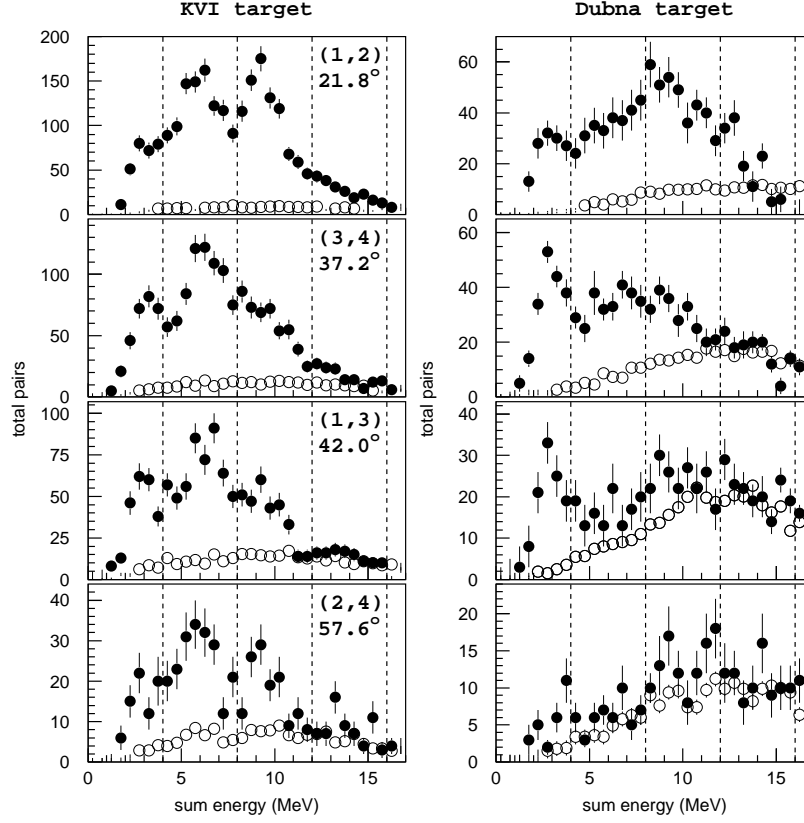


Figure 2: Sum-energy spectra for e^+e^- pairs following (predominantly) the $^{11}\text{B}(d,n)^{12}\text{C}$ reaction at 1.65 MeV using KVI and Dubna targets for correlation angles at 21.8° , 37.2° , 42.0° and 57.6° . The solid respectively open circles represent the total coincidence yield and the yield of accidental coincidences. A 4 MeV wide binning used in Fig. 3 is indicated with solid vertical lines.

a factor two below—though within 1σ compatible with—the value of $(1.6 \pm 0.7) \cdot 10^{-3}$ given in [2, 3]. An α_X value of 18 ± 7 has been derived with Eq. 1 and listed in Table 1. The fair agreement of this enhancement with the previous observation [2, 3] motivates a high statistics experiment [26] in the future.

3. Discussion of the results

In light nuclei the experimental γ -ray transition width Γ_γ from isospin mixed levels can be expressed as the sum of the scalar and isovector transition width Γ_S and Γ_V . The transition strength T_γ is defined as the transition width Γ_γ divided by the Weisskopf estimate or unit (Γ_W or w.u). For transitions to pure $T=0$ states, it is the sum of the separate isoscalar and isovector strength T_S and T_V , scaled by the

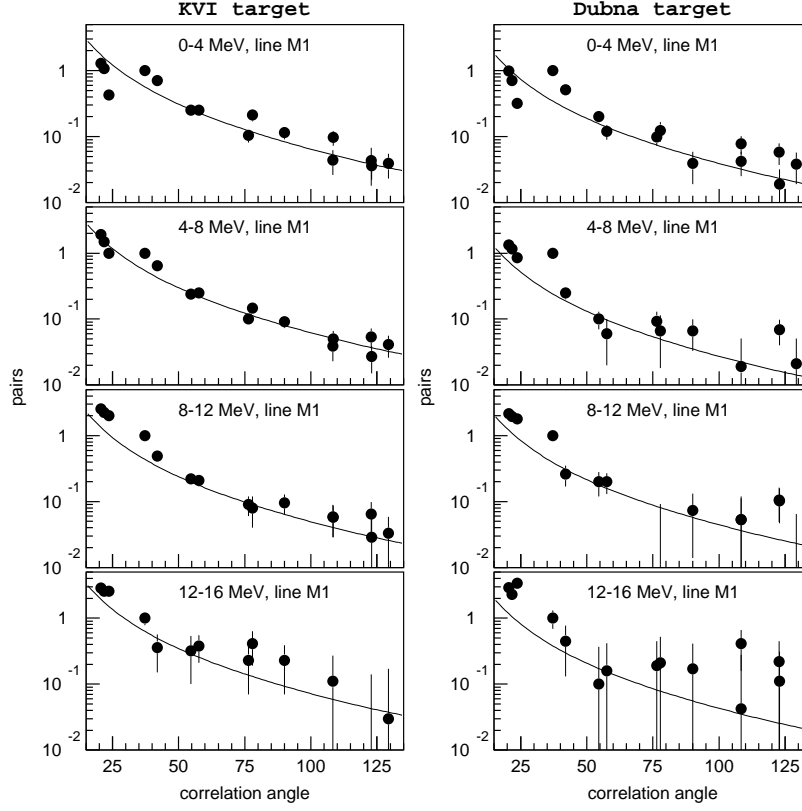


Figure 3: Angular correlations for e^+e^- pairs with sum-energy intervals 0-4 MeV, 4-8 MeV, 8-12 MeV and 12-16 MeV, produced in the $^{11}\text{B}(d,n)^{12}\text{C}$ reaction at 1.65 MeV using two different targets (left: KVI, right: Dubna). The curves are parameterised functions[18, 25] of theoretical IPC distributions for M1 transitions fitted through the data.

T=0 (T=1) fraction x ($1-x$) in the depopulating level, according to:

$$T_\gamma = \frac{\Gamma_\gamma}{\Gamma_W} = \frac{\Gamma_S}{\Gamma_W} + \frac{\Gamma_V}{\Gamma_W} = xT_S + (1-x)T_V. \quad (2)$$

A compilation of known transitions strengths T_V and T_S for pure isovector ($\Delta T=1$, $x=0$) respectively isoscalar ($\Delta T=0$, $x=1$) transitions has been made for self-conjugate ($A = 2Z$) nuclei by Skorka et al.[27]. Histograms of the logarithm of the strength for both cases are shown in Figs. 5a and 5b. We assume that for unmeasured transitions the probability of the isoscalar respectively isovector strength is according to these distributions.

Both (on a log-scale) Gaussian shaped distributions have a FWHM corresponding to two orders of magnitude, and standard deviations of factors 7.4 and 10.6 respectively.

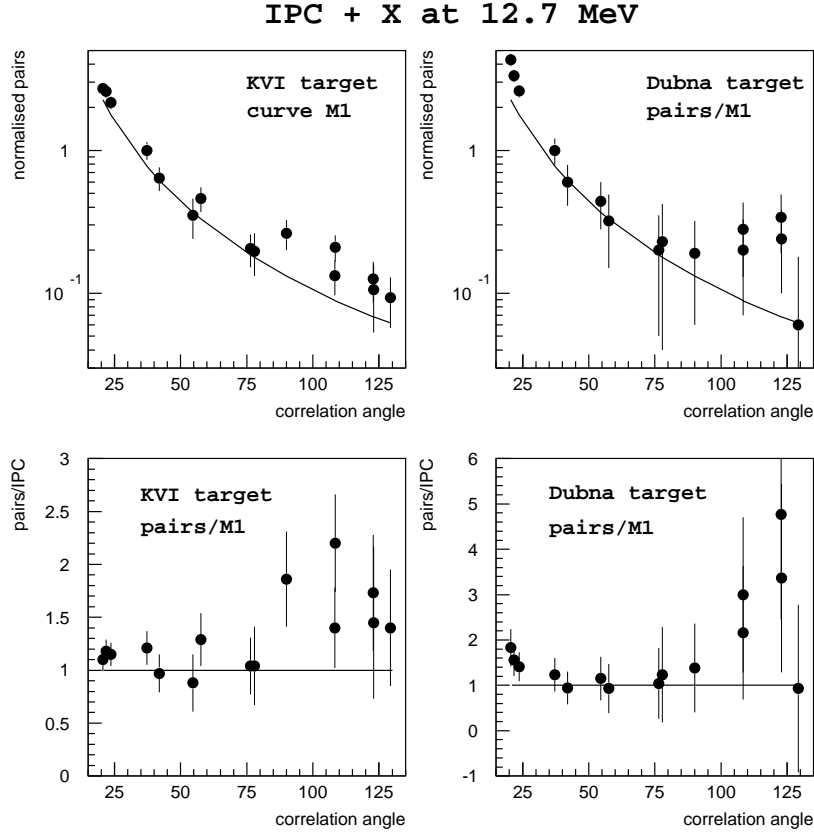


Figure 4: *Top: Angular correlations for sum-energy peaks from internal pairs at 12.71 MeV produced in the $^{11}\text{B}(d, n)^{12}\text{C}$ reaction at 1.65 MeV, using the two targets (KVI, Dubna). The curves represent theoretical IPC values for M1 transitions fitted through the data. Bottom: The experimental values (from the top) divided by the theoretical IPC distributions.*

The average values for the isovector respectively isoscalar transitions were found [27] as $T_V^{ave} = 0.395$ and $T_S^{ave} = 4.97 \cdot 10^{-3}$. They are indicated in Fig. 5. The ratio T_S^{ave}/T_V^{ave} is 0.0126, in fair agreement with the value of 0.0082 given by de Shalit and Feshbach [28] in the long wave length limit.

The levels at 12.71 and 15.11 MeV in ^{12}C have nearly pure $T=0$ respectively $T=1$ character [16]. A T_S value for the 12.71 MeV ground state transition has been derived using Eq. 2 while taking the average T_V value [27] with an error such as to include all T_V values of Table 2. The small error in T_V for the 15.11 MeV transition reflects the small value of x in Eq. 2. This specific T_S/T_V ratio, 0.0129 ± 0.0024 , is in good agreement with T_S^{ave}/T_V^{ave} and also with the theoretical expectation. The isospin structure of these essentially pure transitions is thus sufficiently well understood to be used for further analysis.

For consistency evaluation the X -boson scenario can be tried out as *analyser* of isoscalar width and consequently strength. Using Eq. 1 the isoscalar and isovector transition widths Γ_S and Γ_V can straightforwardly be derived as

$$\Gamma_S = \Gamma_\gamma \left(\frac{\alpha_X}{\alpha_X^0} \right), \quad \Gamma_V = \Gamma_\gamma \left[1 - \left(\frac{\alpha_X}{\alpha_X^0} \right) \right]. \quad (3)$$

E_R MeV	$T=0$ x	E_γ MeV	Γ_γ eV	Γ_W eV	Γ_S eV	Γ_V eV	T_S	T_V
12.71	0.9979 ± 0.0012	12.71	0.35 ± 0.05	43.2	0.30 ± 0.04	0.05 ± 0.04	$(7.0 \pm 1.3) \cdot 10^{-3}$	0.39 ± 0.28
15.11	0.0021 ± 0.0012	15.11	38.5 ± 0.8	70.8	-	38.5 ± 0.8	-	0.54 ± 0.01
17.64	0.05 ± 0.01	17.64	16.7 ± 0.8	113.0	1.0 ± 0.4	15.7 ± 0.8	0.18 ± 0.09	0.15 ± 0.02
		14.64	8.2 ± 0.4	64.5	0.5 ± 0.2	7.6 ± 0.5	0.15 ± 0.07	0.12 ± 0.01
18.15	0.90 ± 0.05	18.15	3.0 ± 0.3	123.0	≤ 0.95	2.7 ± 0.3	$\leq 8.6 \cdot 10^{-3}$	0.22 ± 0.12
		15.15	3.8 ± 0.4	71.5	1.6 ± 0.9	2.2 ± 1.0	$(2.5 \pm 1.4) \cdot 10^{-2}$	0.30 ± 0.14

Table 2: *Parameters of γ -decay properties for M1 transitions depopulating 1^+ levels in ^{12}C and ^8Be . Listed are the resonance energy E_R , the $T=0$ fraction of the level expressed in the parameter x , the transition energy E_γ , the γ -width Γ_γ , the Weisskopf estimate Γ_W , the isoscalar and isovector partial widths Γ_S and Γ_V , and the corresponding transition strengths T_S and T_V .*

From the average α_X value of 21 ± 6 for the 12.71 MeV ground state transition (see Table 1) a maximum boson-nucleon coupling strength $\alpha_X^o = 24 \pm 8$ can be expected for a pure isoscalar transition. The width parameters Γ_S and Γ_V for the M1 transitions under investigation calculated using Eq. 3 are listed in Table 2. The related strength parameters T_S and T_V , taking the old literature isospin assignments [19, 20], are included in Table 2 and in Fig 5.

The T_V values are (on the log-scale) all within 0.5σ in the middle of the distribution in Fig 5 (top). In Fig 5 (bottom) the T_S values are more scattered: those for the 17.64 and 14.64 MeV are at the tail (1.5σ) of the distribution. Within the typical errors in Γ_S ($\sim 50\%$, see Table 2), they are factors 36 and 30 enhanced with respect to the average T_S value (Ave).

The deduced T_S values for the transitions from the 18.15 MeV level are within 0.5σ consistent with the average T_S value. The relative smallness of the upper limit for the T_S value of the 18.15 MeV transition—about a factor 20 below the T_S values for the 17.64 decay—could explain the absence of a visible anomaly. To test the scenario in this case would require at least an order of magnitude higher accuracy in the measurement, which is at present difficult to attain.

4. Summary

Results of two dedicated experiments are reported yielding further indications for an anomaly at 9 MeV/ c^2 in the angular correlation of IPC. The first experiment (^8Be) shows a deviation from IPC at large correlation angles presumably due to the same anomaly in the transition to the first excited state. The second experiment (^{12}C) shows a relatively large anomaly at 9 MeV/ c^2 albeit with limited statistics. Both results are compatible with an X -boson scenario where the boson-nucleon coupling strength is proportional to the isoscalar strength in the M1 transition. Exploiting isospin structure as a guideline, further high statistics experiments are needed to establish the nature of the anomaly.

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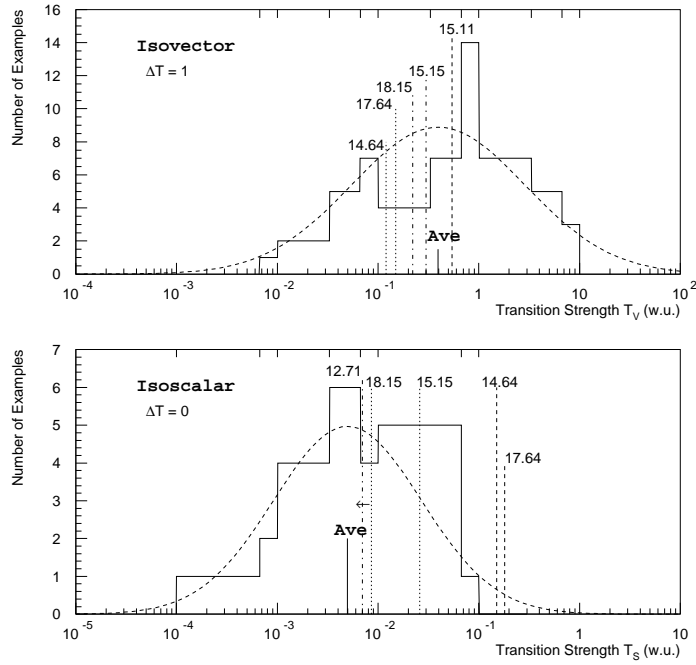


Figure 5: A histogram for measured examples of iovector (top) and isoscalar (bottom) transition strength expressed in Weisskopf units (w.u.) on a log-scale. Dashed lines are Gaussian fits through the histograms. Straight vertical lines show the average values denoted by **Ave**. Vertical lines represent T_V and T_S values, derived using equation 3, for the transitions presently under investigation.

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